32-Channel Analogue Input Card

for the serial (RS232) port

By George Vastianos

Student of Electronics Department, Technological Educational Institute of Piraeus, Greece

This project is a card with 32 analogue inputs with 12-bit resolution each for external connection to the serial port. The feature par excellence of the present project is the way it communicates with the computer. Read on!

Most commercially available cards for analogue voltage capturing include a microcontroller or a UART chip for the serial communication. The card described in this article does not have any of the above chips because its design is based on direct accessing of PC internal UART registers which arrange the conversion from serial to parallel.

About the serial port

Serial ports are mainly used for communication between computers or between computers and peripherals such as a modem or a mouse. The controller of the PC internal RS232 port is nearly always a UART (Universal Asynchronous Receiver Transmitter) chip fitted on the motherboard. The chip works as a serial-to-parallel and parallel-to-serial adapter.

A computer may have one to four serial ports (COM1 through COM4). As shown in **Table 1**, each port occupies eight locations in the I/O memory map.

The basic lines used by a UART for all serial communication (transmission and reception), are called TXD and RXD. Also a group of extra lines (DCD, DSR, RTS, CTS, DTR, RI) is used to establish different types of serial communication. Some of these extra lines work as inputs, others as outputs. Each of these (except RXD) may be controlled through a bit of a UART register, see **Table 2**.

The voltage levels of the serial (RS232) port are different from TTL levels. So, for logic ‘1’ the voltage is –12 V and for logic ‘0’ the voltage is +12 V (nominal values).

The hardware

With reference to the block diagram of the circuit shown in **Figure 1**, the inputs have been divided into four groups of eight inputs (00-07, 08-15, 16-23, 24-31) which are taken to the A-to-D Converter (ADC) units. The four ADC output lines are passed to

Technical Specifications

Number of inputs:	32
Type of inputs:	Analogue (resolution 12 bits, $V_{in(min)} = 0$ Vdc, $V_{in(max)} = 5$ Vdc)
Connection:	Serial Port (RS232)
Communication:	direct access of PC internal UART registers
Power Supply:	9-15V DC
Supply requirement:	approx. 30 mA (stand-by)

Table 1. UART Internal I/O Addresses

Register Name	COM1	COM2	COM3	COM4
Transmit/Receive Buffer	3F8h	2F8h	3E8h	2E8h
Interrupt Enable Register	3F9h	2F9h	3E9h	2E9h
Interrupt Identification Register	3FAh	2FAh	3EAh	2EAh
Line Control Register	3FBh	2FBh	3EBh	2EBh
Modem Control Register	3FCh	2FCh	3ECh	2ECh
Line Status Register	3FDh	2FDh	3EDh	2EDh
Modem Status register	3FEh	2FEh	3EEh	2EEh
Scratch Pad Register	3FFh	2FFh	3EFh	2EFh

Table 2. RS232 Data/Control Line Addresses (I/O Map)

Pin Name	25-pin connector	9-pin connector	COM1	COM2	COM3	COM4	Bit	I/O
TXD	pin 2	pin 3	3FBh	2FBh	3EBh	2EBH	6	O
RXD	pin 3	pin 2	3FCh	2FCh	3ECh	2ECH	0	I
RTS	pin 4	pin 7	3FDh	2FCh	3ECh	2ECH	1	O
CTS	pin 5	pin 8	3FEh	2FEh	3EEh	2EEH	4	I
DSR	pin 6	pin 6	3FEh	2FEh	3EEh	2EEH	5	I
RI	pin 22	pin 9	3FEh	2FEh	3EEh	2EEH	6	I
DCD	pin 8	pin 1	3FEh	2FEh	3EEh	2EEH	7	I

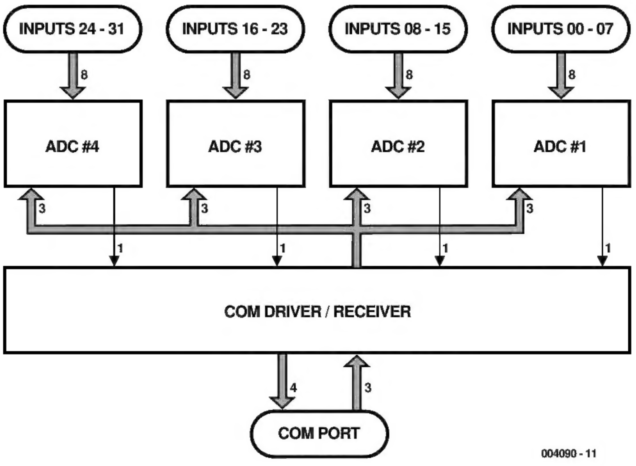

Figure 1. Block diagram of the 32-channel Analogue Input Card for the RS232 Port.

Table 3. Channel allocation on Connectors K2/K3.

K3		K2	
Channel	Pin Number	Channel	Pin Number
00	33	16	33
01	31	17	31
02	29	18	29
03	27	19	27
04	25	20	25
05	23	21	23
06	21	22	21
07	19	23	19
08	15	24	15
09	13	25	13
10	11	26	11
11	9	27	9
12	7	28	7
13	5	29	5
14	3	30	3
15	1	31	1

the COM Driver/Receiver Unit which handles the conversion from TTL level to RS232 level. Four inputs are used on the serial port: CTS, DSR, RI, and DCD. Three outputs of the serial port (TXD, DTR, RTS) are used for the selection of the inputs we want to read (via the ADC's communication protocol). After conversion from RS232 to TTL, the group select signals are passed to the ADC select inputs.

Practical circuit

In the schematic circuit of ADC card, Figure 2, the 32 inputs have been distributed across connectors K3 and K2. The correspondence between the inputs and the connectors can be seen in **Table 3**.

All connector inputs are taken directly to the inputs of the MAX186ADCs (IC1-IC4) without pull-up or pull-down resistors for termination. This allows you, the user, to choose the best type of termination, according to the application. Each of the capacitor pairs C1-C6, C2-C7, C3-C9 and C10-C8 consists of a ceramic (or MKT) capacitor of 100 nF an 4.7-µF electrolytic type in parallel. The pairs decouple the supply voltage, suppress high- and low-frequency noise and so improve the stability of the circuit.

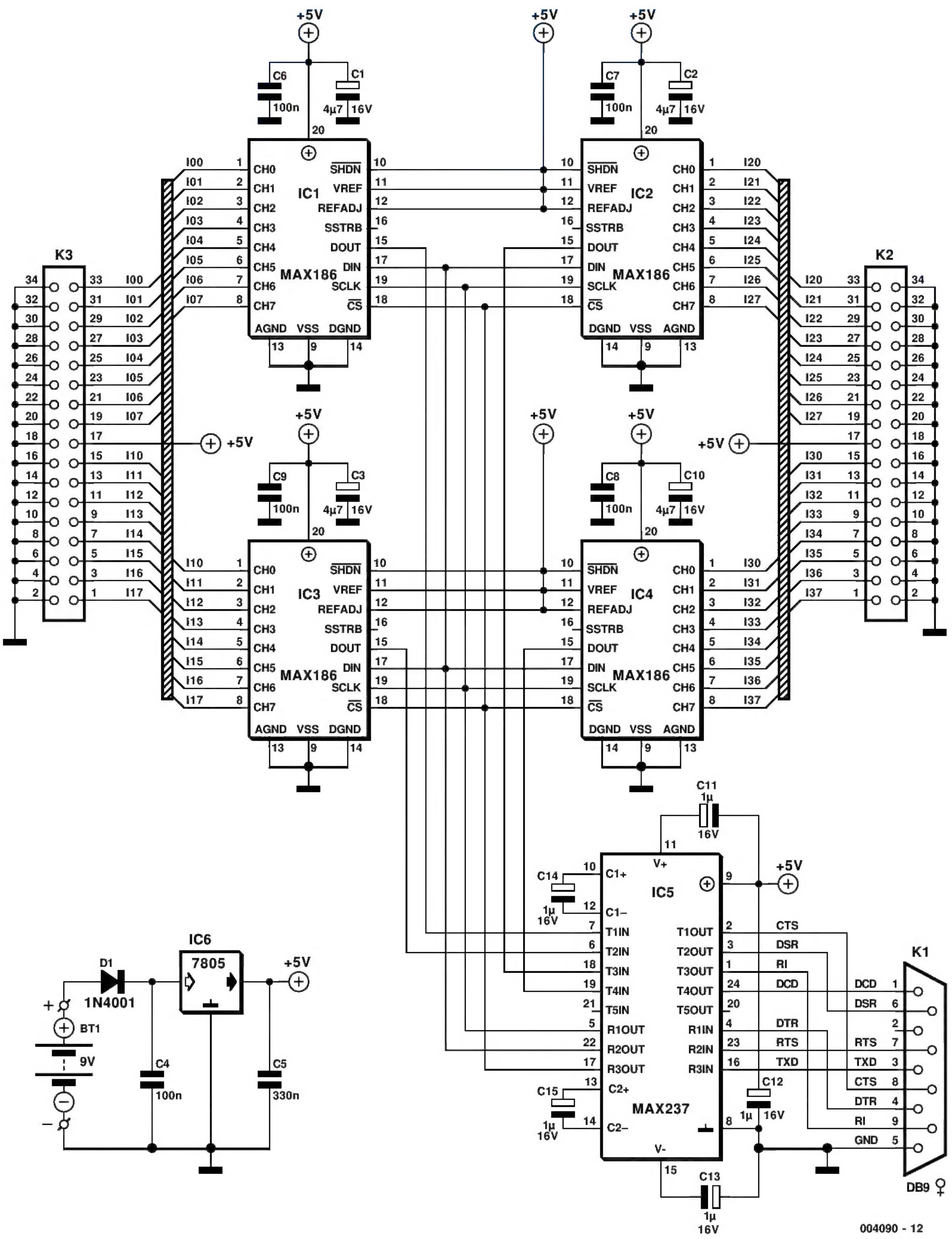

Figure 2. Practical circuit of the 32-channel ADC card.

The last unit is the COM Driver/Receiver Unit, which includes its own regulator so that the card does not need a regulated power supply to work. In the schematic diagram, the Max237 (IC5) works as an RS232 driver/receiver. It converts three channels from RS232 to TTL, and five channels from TTL to RS232. The five capacitors C11 through C15 (1 µF) are used by the MAX237 for voltage doubling. This is necessary to allow the driver section to produce a voltage of 10 V (from the 5 V supply) for the five RS232 outputs. The MAX237 contains an inverter in each channel. Circuit IC6, the ubiquitous 7805, together with satellite capacitors C4 and C5, steps the raw supply voltage down to a regulated line of 5 V. Diode D1 protects the circuit against input supply voltage reversal. The circuit is suitable for powering by a 9-volt battery.

Construction

The circuit is best built on the printed circuit board with the layout shown in **Figure 3**. This single-sided PCB is available ready-made through the Publishers' Readers Services under order code **004090-1**.

Construction of the board should not present problems if you work carefully using the component overlay and the information in the parts list. There are 12 wire links on the board. Despite the fact that wire links are the simple but essential parts, we know from experience that they are often forgotten, and many reported problems with our construction projects can be traced down to absent wire links. So fit the 12 links before any other components.

The 7805 regulator is only lightly loaded by the circuit and can make do without a heatsink.

Pay attention to the orientation of polarized parts (diode, electrolytic capacitors).

We recommend using sockets for all ICs (except of course the 7805).

The software

The software for the communication with the card has been developed in QBASIC. The communication routine is called `CARD32AI` — its source code is available as a free download.

This routine may be called from every program written in QBASIC if you stick to the following syntax:

```
CALL CARD32AI (COMADDRESS, CHANNEL())
```

Where

`COMADDRESS` is the Integer type variable containing (before the call) the base address of the serial port. Probable values of this variable are `&H3F8` for COM1, `&H2F8` for COM2, `&H3E8` for COM3 and `&H2E8` for COM4.

`CHANNEL()` is the matrix integer type variable (with pointers from 0 to 31), which (after the call) contains the arithmetic value of each separate channel with values 0 to 4095.

A demonstration program has been

COMPONENTS LIST

Capacitors:
C1,C2,C3,C10 = 4µF7 16V radial
C4,C6-C9 = 100nF
C5 = 330nF
C11-C15 = 1µF 16V radial

Semiconductors:
D1 = 1N4001
IC1-IC4 = MAX186-CPP
IC5 = MAX237CNG
IC6 = 7805

Miscellaneous:
K1 = 9-way sub-D socket (female), angled pins, PCB mount
K2,K3 = 34-way boxheader
PCB, order code 004090-1 (see Readers Services page and Elektor Electronics website)
Project software: free download from Publishers' or author's website.

developed for testing the card. A screenshot of the program in action is shown in **Figure 4**.

To change the serial port address, simply use the keys <1> to <4>. If you want to quit, just press <Esc>.

Free download

The source code of the communication routine (CARD32AI.SUB) and the demonstration program (32AICARD.BAS), with an executable version of the demonstration program (32AICARD.EXE) have been packed into a single zip file which may be downloaded from the author's website at

http://www.robofreak.xs3.com

or from the Free Downloads section (June 2001 items) of the Publishers' website at

http://www.elektor-electronics.co.uk

At the express request of the author, no floppy disks will be sold containing the project software. Readers interested in obtaining the software but not having Internet access are requested to contact the Editor in writing.

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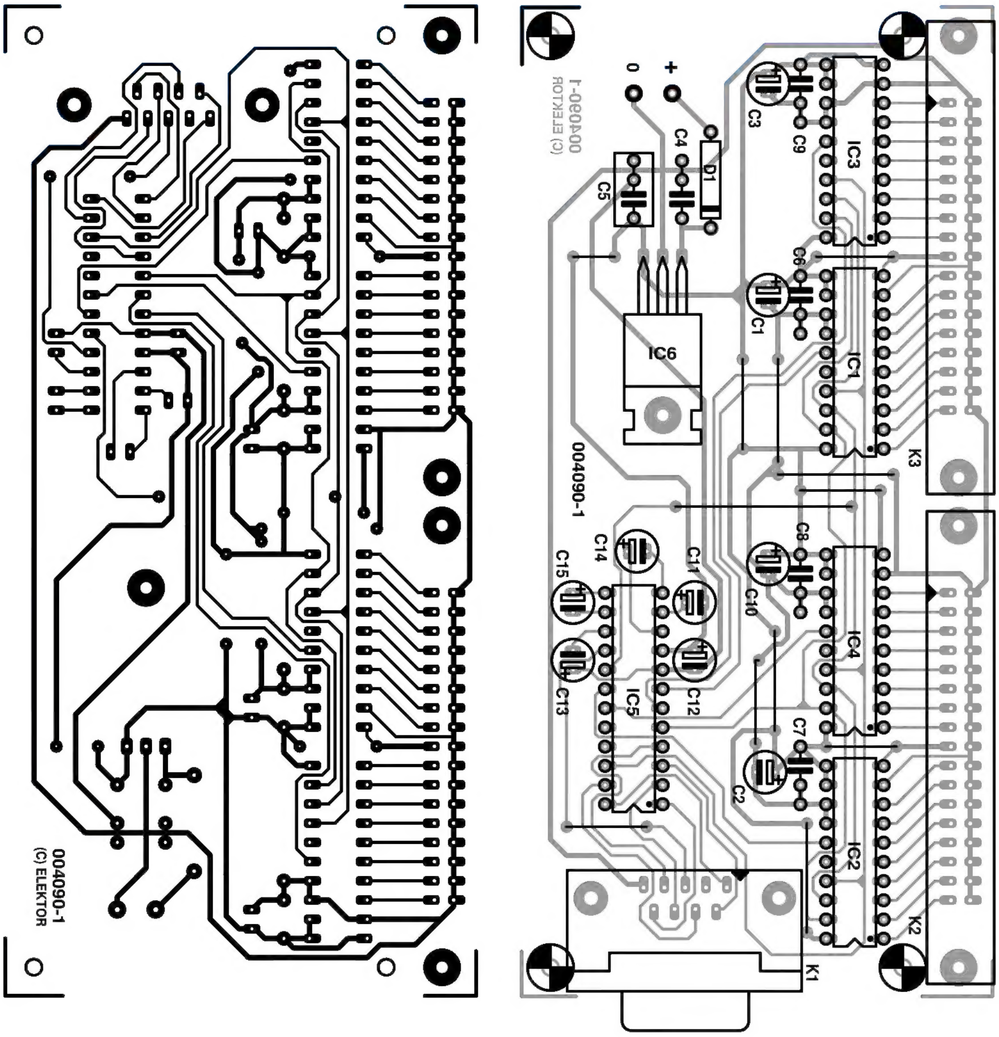
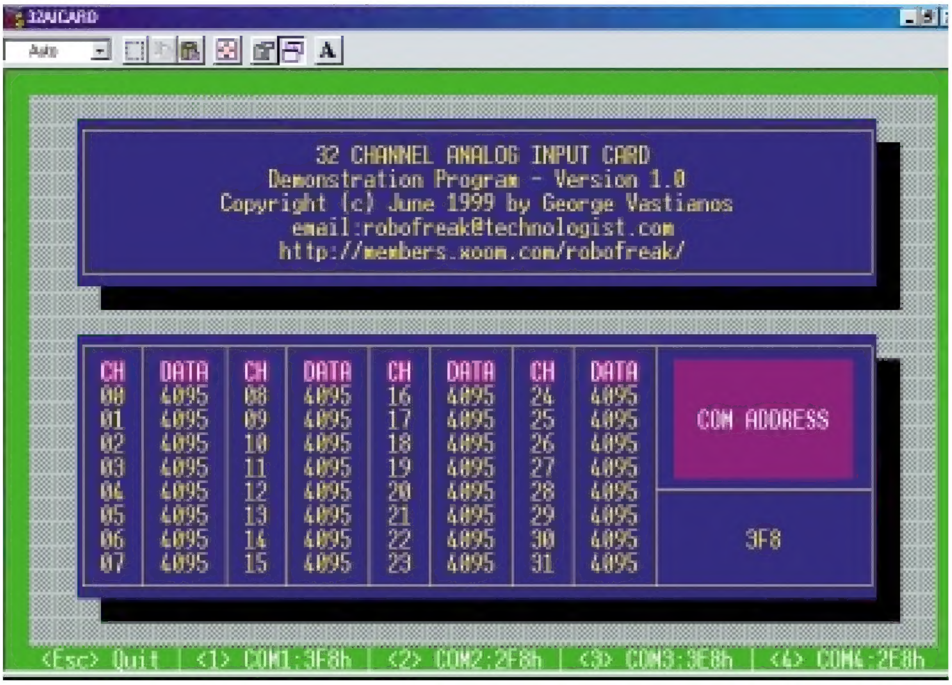


Figure 3. PCB artwork (board available ready-made).



```
32 CHANNEL ANALOG INPUT CARD
Demonstration Program - Version 1.0
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email:robofreak@technologist.com
http://members.xoom.com/robofreak/

CH  DATA   CH  DATA   CH  DATA   CH  DATA
00  4095   08  4095   16  4095   24  4095     COM ADDRESS
01  4095   09  4095   17  4095   25  4095
02  4095   10  4095   18  4095   26  4095
03  4095   11  4095   19  4095   27  4095
04  4095   12  4095   20  4095   28  4095
05  4095   13  4095   21  4095   29  4095        3F8
06  4095   14  4095   22  4095   30  4095
07  4095   15  4095   23  4095   31  4095

<Esc> Quit | <1> COM1:3F8h | <2> COM2:2F8h | <3> COM3:3E8h | <4> COM4:2E8h
```

Figure 4. The demo program in action.